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STATISTICAL ANALYSIS OF COLLECTED TIMES BETWEEN FAILURE AND TIMES TO REPAIR OF EASI-MINER AT OBED MINE

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STATISTICAL ANALYSIS OF COLLECTED TIMES BETWEEN FAILURE AND TIMES TO REPAIR OF EASI-MINER AT OBED MINE

by

J.K. Szymanski* and C. Williams**

ABSTRACT

A cooperative effort in 1986 and 1987 produced a SLAM II simulation model capable of realistically predicting operation performance under a wide variety of system scenarios for Obed's Huron Easi-Miner. A time study of Easi-miner coaling operations at the mine was conducted in November, 1986. The short study period did not allow sufficient time to collect the required amount of data for evaluating the mean time between failures and mean time to repair. This report deals with the statistical analysis of time to repair and time between failures data for subsequent use in the simulation of Easi-miner operation. Validity tests suggest that a Log-normal distribution may best describe the spread of these variables.

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ANALYSE STATISTIQUE DES TEMPS CONSIGNES ENTRE LES DEFAILLANCES ET LES TEMPS DE REPARATION DE LA EASI-MINER A LA MINE OBED

par

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RESUME

En 1986-1987, un effort de collaboration a produit un modèle de simulation SLAM II capable de prévoir de façon réaliste le rendement de la EASI-MINER HURON d'OBED dans divers scénarios. Une étude de temps de la Easi-Miner a été effectuée à la mine en novembre 1986. Cette courte étude n'a pas permis de recueillir des données suffisantes pour évaluer le temps moyen entre les défaillances et le temps moyen de réparation. Ce rapport porte sur l'analyse statistique du temps de réparation et du temps entre défaillances pour fin d'utilisation ultérieure dans la simulation du fonctionnement de la Easi-miner. Des essais de validité indiquent qu'une distribution log-normale décrirait le mieux la répartition de ces variables.

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INTRODUCTION

A computer model has been developed to simulate operation of the Easi-miner with trucks in open pit mines. In this model stochastic simulation is used to reflect the random variations in duration of various activities. This gives a realistic representation of the processes under study. During the period of November 10-19, 1986 data was collected from an operating mine through a time study of Easi-miner and trucks network cycle times (1). The short period of the study did not allow the collection of the required number of data points to allow a definitive evaluation of the mean time between failures and time to repair. These variables have been introduced in stochastic simulation models to reflect their effect on production rates. This data was collected from production reports for a period of one year. The data was obtained under the operating and environmental conditions in which the Easi-miner is used and is therefore somewhat site specific.

STATISTICAL ANALYSIS OF COLLECTED DATA

This section deals with the collection and analysis of the data. Appropriate distribution curves were fitted through the data collected from the production reports. Validity tests of the chosen distributions were made using the maximum deviations of the times from the theoretical curve. The residuals, when tested by the stabilized probability plot, showed Log-Normal distributions (Figures 1 and 2).

The probability density function of the Log-Normal distribution is:

$$f(x) = \frac{1}{\sigma \times \sqrt{2\pi}} \quad \exp \; - \tfrac{1}{2} \left[\frac{\ln x - \mu}{\sigma} \right]^2$$

The parameters μ and σ are related to the mean and variance by the following theoretical relationship:

$$\text{mean} = e^{\mu + \frac{\sigma^2}{2}}$$

$$\text{variance} = e^{2\mu+\sigma^2} (e^{\sigma^2} - 1)$$

The following are the maximum likelihood estimates of the Log-Normal distribution parameters (Table 1):

Table 1 The estimates of the Log-Normal distribution

Data type	μ	σ	Mean	Variance	Chi-square	P-value
Time between failure	6.9055	.8996	1495.89	11028.13	4.1926	.8414031
Time to repair	4.9158	.9252	321.11	103.51	1.5640×10^2	.9004743

Figures 3 and 4 give the histograms and the estimated density functions for the Log-Normal distribution obtained from the collected data. From this table we can see that the correlation coefficient for the failure times and repair times are 0.84 and 0.90 respectively. This can be judged to be satisfactory to allow the theoretical distribution to be used in the stochastic simulation model.

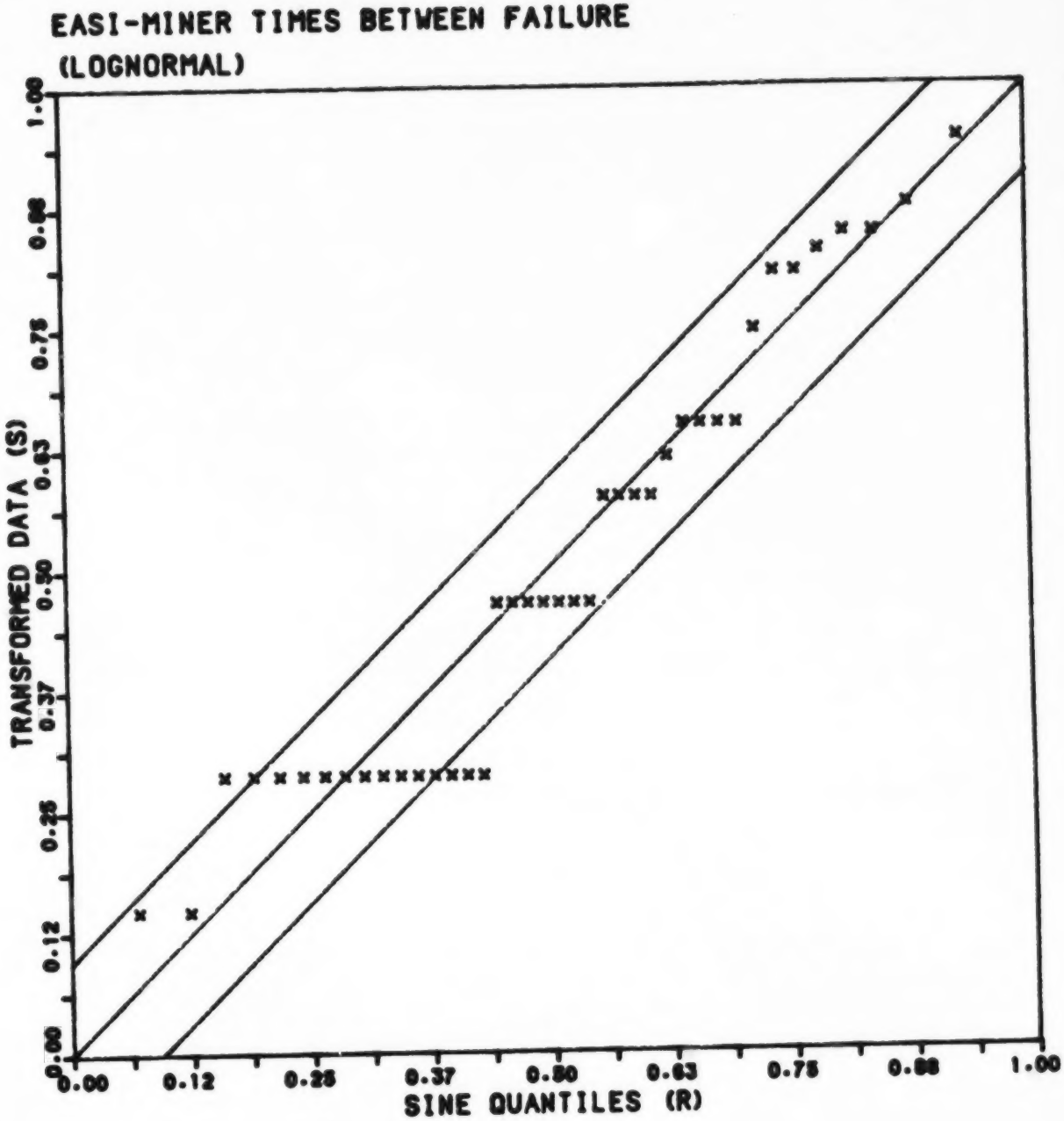

Fig. 1 The stabilized probability plot for times between failure of Easi-Miner.

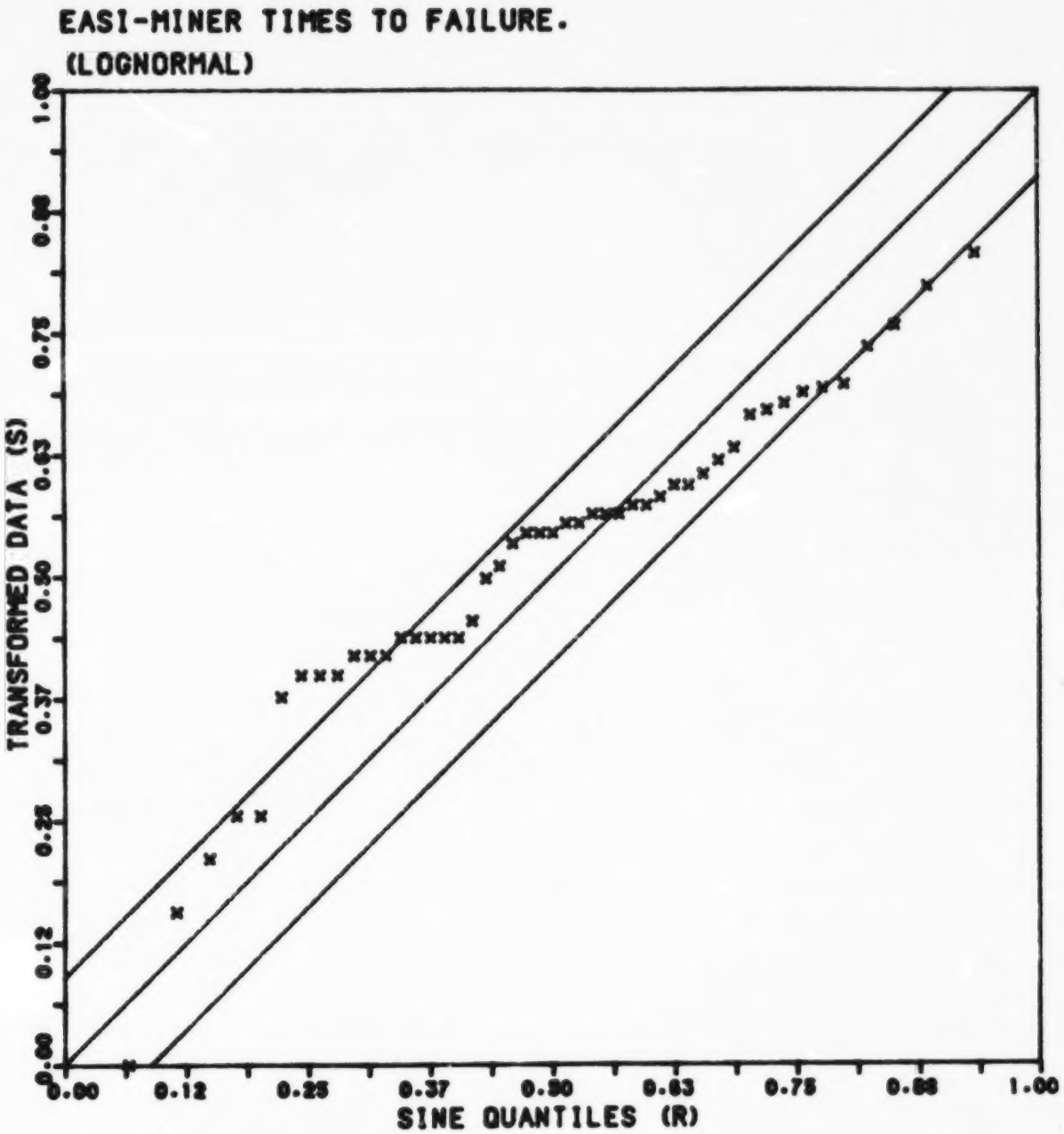

Fig. 2 The stabilized probability plot for times to repair of Easi-Miner.

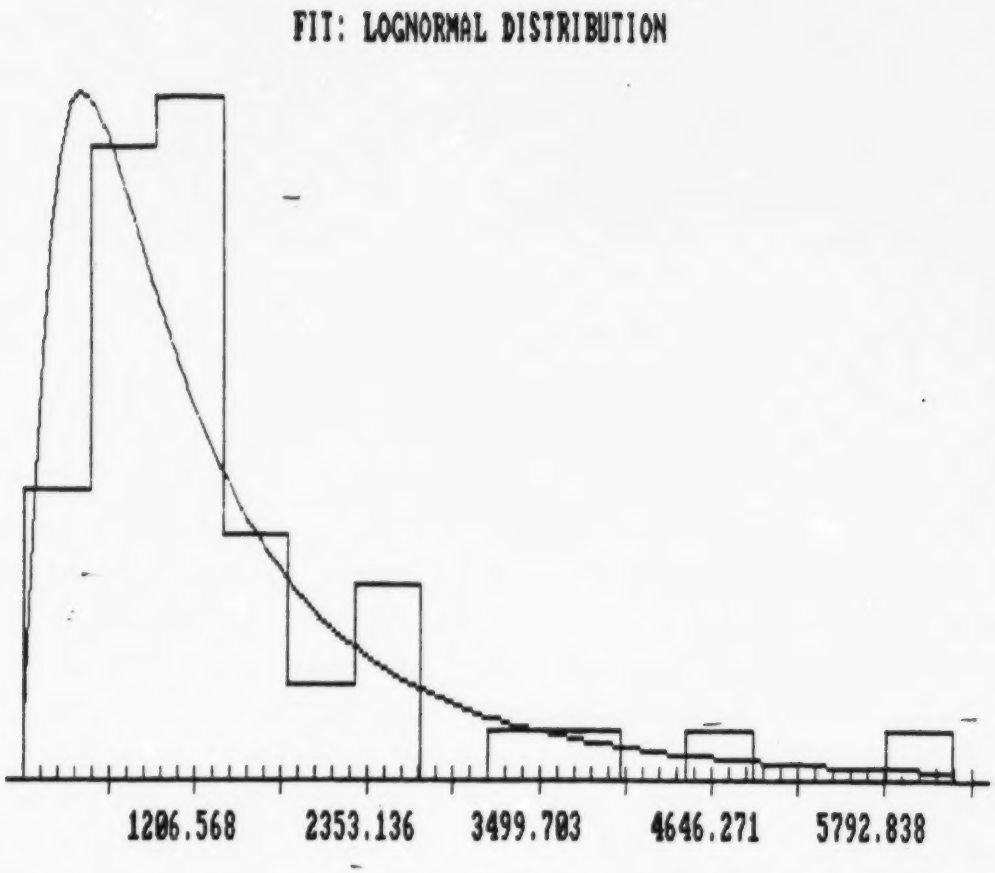

Fig. 3 Histogram and the estimated density function for the Log-Normal density function of the times to repair.

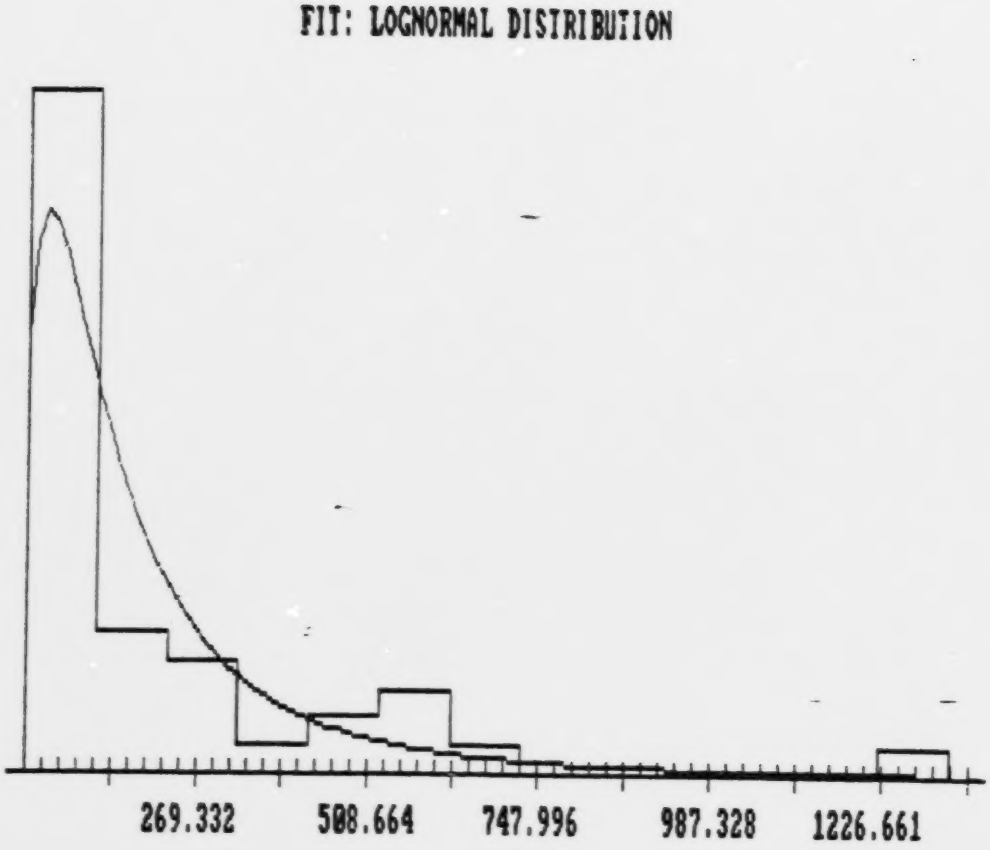

Fig. 4 Histogram and the estimated density function for the Log-Normal density function of the times between failure of Easi-Miner.

CONCLUSIONS

Failure and repair times taken from the mine's production reports provided data of sufficient quality to allow a theoretical relationship of their occurrence to be determined. This relationship will be used in a stochastic model to simulate the operation of an Easi-miner working with trucks.

REFERENCES

1. Szymanski, J.K., Heximer, M., Veldhuis, D., and LaRocque, G.H., "An Analysis of Easi-Miner Time Study Data at Obed Mountain Mine"; Division Report, M&ERP/CRL 86-144(TR).